Biomarkers of woodsmoke exposure among wildland firefighters

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Woodsmoke exposure and health effects

- 70-80,000 workers involved in wildland firefighting annually (Harrison et al,, 1995)
- Woodsmoke is complex mixture
  - Hundreds of chemicals (PAHs, aldehydes, etc.)

- Possible respiratory health effects (Naeher et al, 2005)
  - Asthma, infections, lung cancer, COPD
- 40% of firefighter medical problems during ‘88 Yellowstone fires respiratory (Naeher et al, 2005)

Woodsmoke exposure assessment

- Difficult among wildland firefighters
  - Highly transient
    - Area level ≠ personal exposure
  - Spatial/temporal variation
  - Irregular shifts, conditions
- Previous air measurements
  - Particulate matter (PM_{10}, $PM_{3.5}$) (Reinhardt and Ottmar, 2004)
  - Carbon monoxide (CO) (Reinhardt and Ottmar, 2004)
  - Levoglucosan (LG) (Simpson et al, 2004; Lee et al, 2005)
  - Methoxyphenols (MPs) (Dills et al, 2006; Dills et al, 2001)

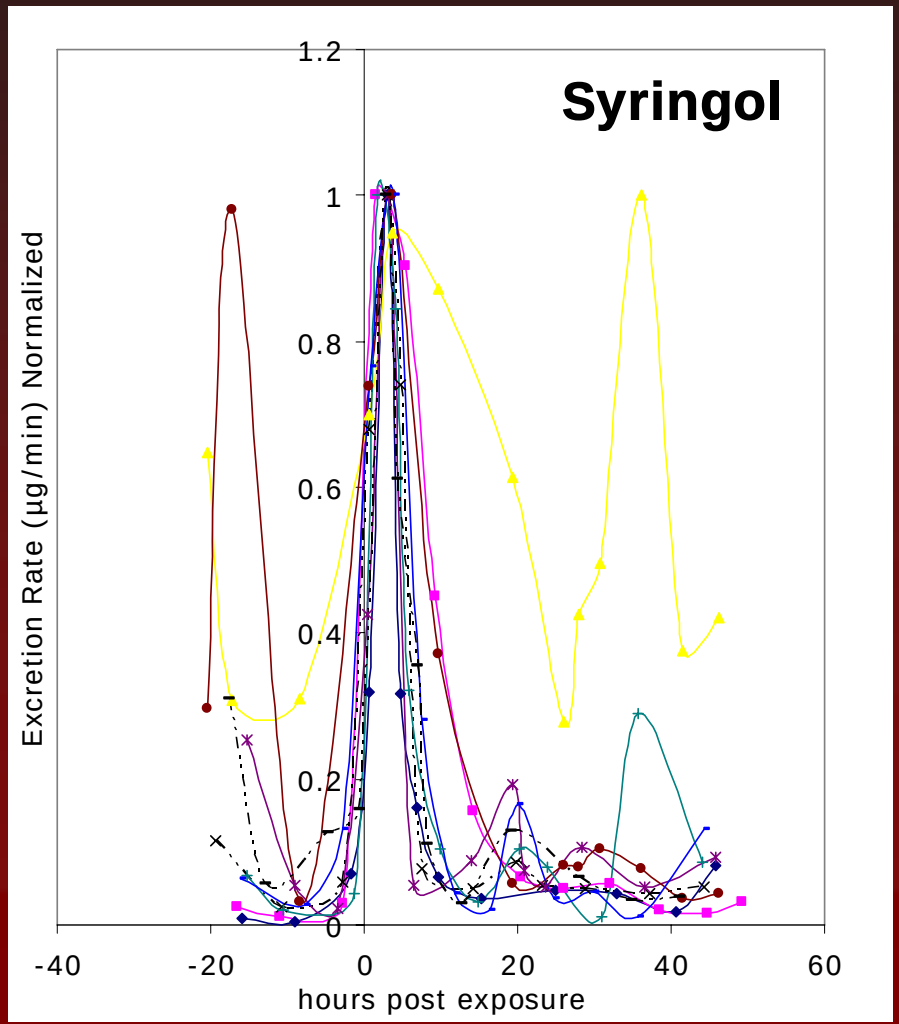
Woodsmoke components: levoglucosan and methoxyphenols

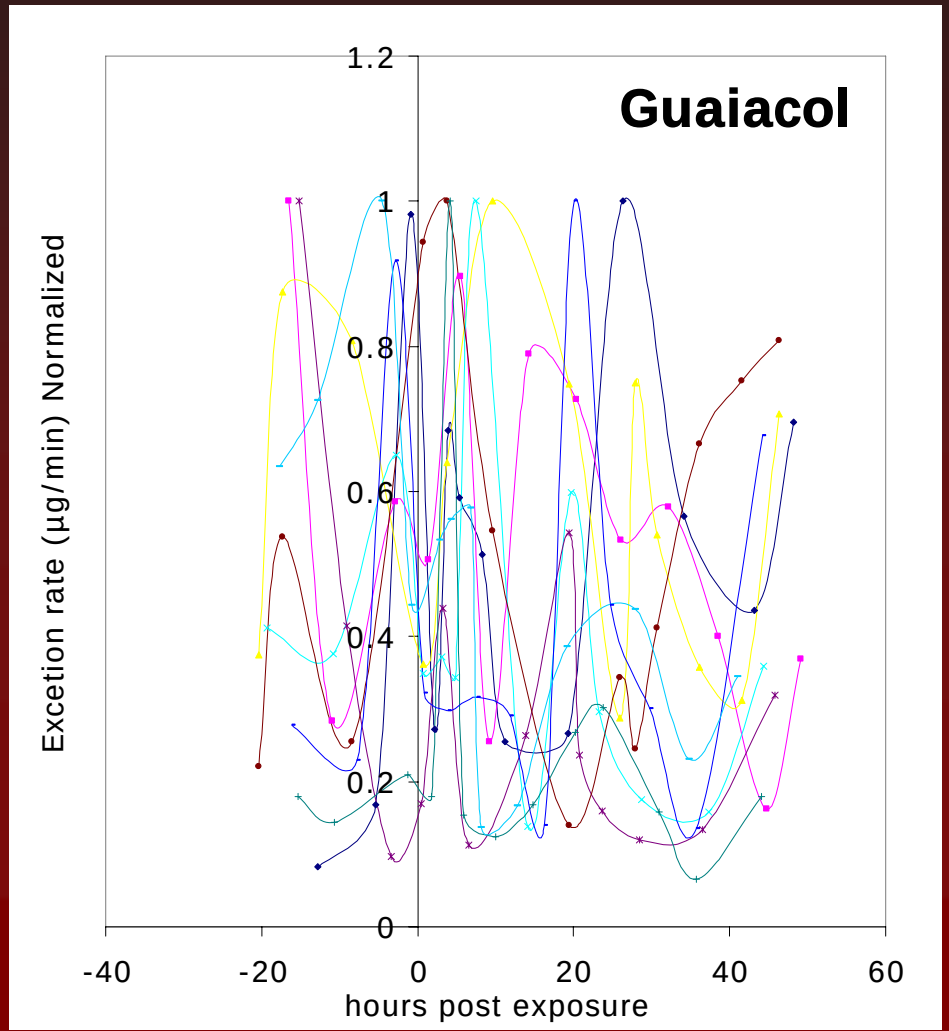
- LG (measured in air)
  - Pyrolysis product of wood polymer cellulose
  - Most abundant organic compound in wildland woodsmoke particles (Lee et al, 2005)
  - Less likely to come from non-woodsmoke sources than PM, CO
- MPs (measured in air and urine)
  - Unique to woodsmoke; derived from lignin pyrolysis
  - Rapid urinary elimination; t1/2 ~ 2-6 hr

Background: ‘campfire’ study

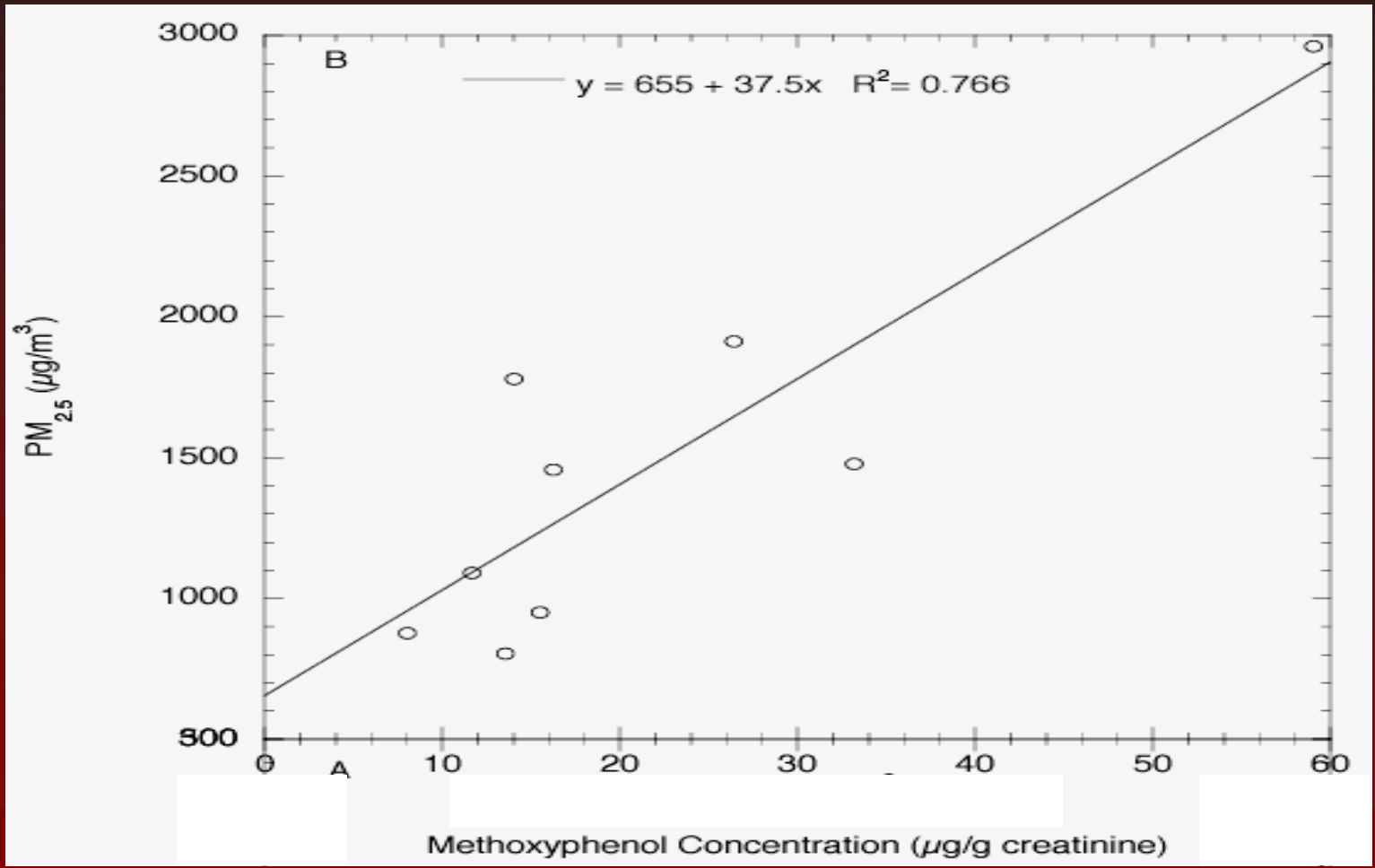
- Nine healthy subjects (Dills et al, 2006)
  - 2 hr managed exposure to mixed hardwood and softwood smoke
  - Personal samples of $PM_{2.5}$, LG, MPs
  - 2 hr average $PM_{2.5}$ conc ~1200 $\mu g/m^3$
  - Serial urine samples over 72 hrs centered on exposure
  - Dietary restrictions imposed

Excretion rates for syringol and guaiacol from ‘campfire’ study





Dose-response for MP biomarker from ‘campfire’ study



Biomarker is sum of 12-hr average creatinine adjusted urinary concentration for 5 methoxyphenols that showed maximum response to woodsmoke exposure

‘Campfire’ study conclusions

- Urinary concentrations of 5 syringols and guaiacols increased after acute (2 hr) exposure to woodsmoke.
- $t_{1/2}$ for urinary excretion 2-6 hrs
- Biomarker levels increased proportionately with exposure to LG, $PM_{2.5}$
  - Exposure to LG explained ~80% of variability in urinary biomarker

Wildland firefighter pilot study

- Biomarkers may be more accurate measure of woodsmoke exposure than air samples
- Evaluate relationships between $PM_{2.5}$, CO, LG woodsmoke exposure and urinary MPs
- Hypothesis:
  - $PM_{2.5}$, CO, LG concentrations will be highly correlated with cross-shift urinary MP changes

Δ  $\rightarrow \Delta$  ?

Wildland firefighter study methods

- 20 shifts worked by 13 firefighters
  - Part of dataset collected by UGA, CDC
  - Chosen to cover range of $PM_{2.5}$ exposures
- Personal TWA levels of CO, $PM_{2.5}$, LG + qxr
  - CO measured via datalogging monitor
  - $PM_{2.5}$, LG from single filter
  - Smoked/grilled foods, smoking
- Pre- /post-shift urine samples
  - 22 MPs + creatinine

Wildland firefighter study urinary MPs

- Pre-/post-shift MP levels normalized to creatinine levels before analysis (Dills et al, 2005)
  - Correct for temporal variations in urine conc.
- 14 of 22 creatinine-adjusted cross-shift MP changes significant
- 7 highly correlated creatinine-adjusted MPs chosen for MP vs. exposure analysis
  - 4 guaiacols, 3 syringols
  - These MPs analyzed separately and combined into summed guaiacol and syringol variables

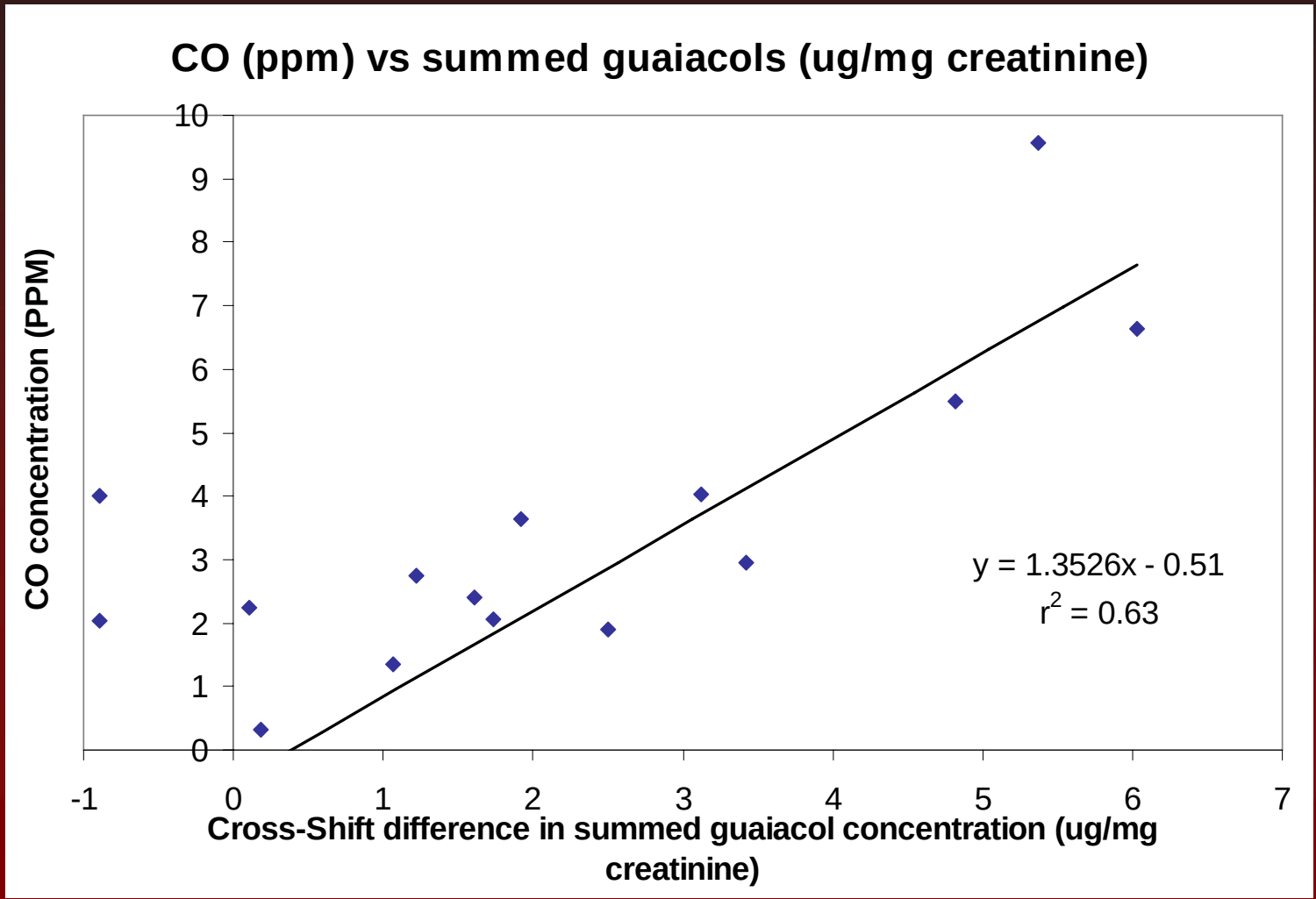
Wildland firefighter study issues

- Urinary MPs and CO levels represent full-shift exposure
- PM/LG pumps often failed during shift
  - Failure times, later exposures in field notes
- Solution: data divided into subsets
  - Full-shift exposure measurements (n = 20 CO, 9 LG, 9 $PM_{2.5}$ measures)
  - All exposure measurements (n = 20 CO, 15 LG, 15 $PM_{2.5}$ measures)

Wildland firefighter study correlations: urinary MPs vs. exposures

- Creatinine-adjusted guaiacols
  - 4 individual and summed guaiacols significantly correlated with full-shift and all CO levels
  - 3 individual and summed guaiacols significantly correlated with all LG levels
  - No significant correlations with $PM_{2.5}$ levels
- Creatinine-adjusted syringols
  - No significant correlations with full-shift or all CO, LG, or $PM_{2.5}$ levels

Wildland firefighter study dose-response for summed guaiacols



Other model r^2: LG vs guaiacols, 0.03; CO+LG vs. guaiacols, 0.79

Wildland firefighter study conclusions

- Significant cross-shift changes in majority (14 of 22) of urinary MPs
- Creatinine-adjusted guaiacols highly associated with CO; smaller association with LG; none with $PM_{2.5}$
- Syringols not associated with CO, LG, PM
- CO explains most variance in MPs

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Future directions and acknowledgements

- Examine exposure and urinary MP relationship in full UGA/CDC dataset
  - Stratify analysis by forest type, activity, etc
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